



Experimental Research on Tone of Liuzhou Dialect Based on Big Data Measurement

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Abstract. Based on big data measurement, this paper analyzes the acoustic parameters such as fundamental frequency and duration of Liuzhou dialect tones, constructs the acoustic patterns of monosyllabic and polysyllabic tones, and employs the Chinese dialect phoneme sound experimental analysis tool developed by Dr. Xiong Ziyu to analyze the correspondence between ancient and modern tones of Liuzhou dialect. The acoustic patterns of monosyllabic and polysyllabic tones, as well as the correspondence between ancient and modern tones, are visualized in the form of spectrograms. The experimental results indicate that: the pattern of monosyllabic tones is flat for Yin Ping, low-falling for Yang Ping, high-falling for Shang, and rising for Qu. The correspondence between ancient and modern tones is characterized by the division of Ping into Yin and Yang, the allocation of Zhuo Shang to Qu, the lack of division between Yin and Yang in Qu, and the reading of Ru as Yang Ping. The polysyllabic tone linkage patterns are largely consistent, retaining the main characteristics of monosyllabic tones without tonal position changes, only differing in tonal values, which are tonal position variants.

Keywords: Liuzhou Dialect, Data Corpus, Monogram Tone, Polysyllabic tone, Acoustic Model

1 Introduction

Currently, experimental research on Chinese dialect tones is quite rich. Liu Fu's (1924) "Experiments on the Four Tones" marked the beginning of experimental research on Chinese tones. Subsequently, scholars such as Luo Changpei, Bai Dizhou, and Wang Li also carried out tonal experiments. Shi Feng (1992) proposed the concepts of "tone pattern" and "acoustic space of tone," advocating that the tone pattern is to describe the overall structure of monosyllabic tones in a language or dialect. However, the aforementioned studies on tones are based on a sampling form of analysis within a dialect,

such as selecting 10 syllables each for the Yin Ping, Yang Ping, Shang, and Qu tones in the study of Mandarin. Xiong Ziyu (2012) developed a set of script tools for systematic observation, extraction, and analysis of phonetic acoustic data based on the Praat software ^[9]. This system is capable of comprehensively observing and organizing the evolution and synchronic study of the phonetic characteristics of Chinese dialects (Liu Xinzhong, Zeng Ling, 2020). This system undoubtedly greatly simplifies the work of large-scale phonetic annotation, extraction, and acoustic data analysis, providing convenience for analyzing big data voice samples. Liu Xinzhong, Liang Jiaying (2017), Lin Yuanyang (2020) ^[11], Su Sisi (2020) ^[12], Wu Yanfen, Liu Xinzhong (2021) ^[10], Zeng Ling, Yu Junyi, et al. (2022) conducted full-coverage analysis of tones in dialects such as Mandarin, Cantonese, Min, and Gan based on this system, that is, all commonly used characters carrying tones in a dialect are included in the experimental scope, which facilitates researchers to more intuitively analyze and find the linguistic significance between voices with the help of the physical correlate of tone, fundamental frequency. This kind of empirical research oriented by big data can provide more phonetic details, making phonetic research no longer abstract and homogeneous, but relatively specific.

Liuzhou is located in the central-northern part of the Guangxi Zhuang Autonomous Region, connecting to Luzhai and Xiangzhou counties in the east, adjacent to Laibin in the south, neighboring Xincheng, Luocheng, and Yishu counties in the west, and bordering Rongshui and Rong'an counties in the north. The jurisdiction includes Liujian County to the southwest of the urban area and Liucheng County to the southwest of the urban area ^[1]. In "The Atlas of Languages in China" (2012), under "B2-3 Guangxi Zhuang Autonomous Region - B- Southwestern Mandarin Map" ^[2] Liuzhou dialect is classified as Southwestern Mandarin - Guilin-Liuzhou section - Northern Guangxi subsection.

The research on the single-syllable tones of Liuzhou dialect is quite rich, including traditional phonological studies and comparisons, such as Liu Chunghan (1995), Guangxi Chinese Dialect Atlas (1998), Bi Yanyan (2006), Yang Yu (2009), Luo Ting and Tang Qiyuan (2014), experimental studies include Man Xin (2006), Liu Shanshan (2007), Song Jiayin (2015), etc., as shown in Table 1. From Table 1, it is known that the biggest controversy about Liuzhou dialect is whether it has an entering tone. Liu Chunghan (1995), Man Xin (2006), and Liu Shanshan (2007) recorded that Liuzhou dialect has an entering tone with a tone value of 5 when describing the tones of Liuzhou dialect. However, other scholars believe that Liuzhou dialect only has four tones: level, rising, departing, and going down. Luo Ting and Tang Qiyuan (2014) mentioned that the Liuzhou dialect is influenced by Guangdong dialect or ethnic languages, and there are also a few entering tone rhymes with the rhyme tail being ʔ. The Liuzhou Dialect Dictionary records 13 entering tone characters (including two characters with sound but no corresponding character), most of which are onomatopoeic words or measure words, and the quantity is very small, and not systematic. The author also found similar phenomena in the process of investigation and experiment. Therefore, the author believes that the entering tone cannot be an independent tone category.

The Chinese dialect phoneme sound system is a set of script tools developed by Dr. Xiong Ziyu based on the Praat software for observing, extracting, and analyzing acoustic phonetic data. This system is capable of comprehensively observing and organizing

the evolution and synchronic study of the phonetic characteristics of Chinese dialects (Liu Xinzong, Zeng Ling, 2020 ^[3] This paper will use this system to conduct experimental analysis on the monosyllabic and disyllabic tones of the Liuzhou dialect.

2 Experimental Description

2.1 Experimental Materials and Speakers

In this experiment, two native speakers of Liuzhou dialect, one elderly male and one elderly female, were selected as the subjects. A monosyllabic word list and a disyllabic word list were designed. The monosyllabic pronunciation materials for the elderly male and female speakers were derived from the "Dialect Investigation Word List" ^[4] and the "Complete Syllable Table of Liuzhou Dialect," respectively. The elderly male had a total of 2872 valid audio materials, covering all commonly used characters with tones in Liuzhou dialect; the elderly female had 1035, covering all syllables with tones in Liuzhou dialect.

2.2 Annotation Method

The broadband spectrogram is transformed into a narrowband spectrogram, and the 5th to 10th harmonics are generally used as a reference for annotating tones, excluding the initial dip and final tail parts ^[5]. The occurrence of the initial dip may be due to factors such as the inertia of vocal cord movement and emphasis during pronunciation. The occurrence of the final tail may also be caused by factors such as the inertia of vocal cord movement.

2.3 T-value Conversion Method and Duration Normalization Method

Different speakers have different speech characteristics. The purpose of normalization is to filter out individual characteristics and reduce the differences in pronunciation style during recording, in order to obtain information that is linguistically meaningful. Therefore, this paper has conducted standardized computational processing on the acoustic data of this experiment. The main tasks are to convert the fundamental frequency values of all monosyllabic and disyllabic tones to T-values and to calculate the absolute duration of monosyllabic tones.

The T-value conversion formula is as follows ^[6]:

$$T = (lgx - lgb) / (lga - lgb) * 5$$

In this formula, $\backslash(a \backslash)$ represents the upper limit frequency of the tonal range, which is the maximum value among the average of the fundamental frequency data of the five tones; $\backslash(b \backslash)$ represents the lower limit frequency of the tonal range, which is the minimum value among the average of the fundamental frequency data of the five tones. $\backslash(x \backslash)$ is the frequency of the measurement point.

This experiment combines Zhu Xiaonon's ^[7] algorithm for calculating the absolute duration of monosyllabic tones. The specific steps are as follows: first, place the duration of each tone under 100% of the duration, then multiply the duration data by 0% down to 90%, and calculate the absolute duration value. An XY scatter plot is used to create a graph of T-values and absolute durations. This represents the result of individual self-normalization, and finally, the normalized results of all speakers are averaged to obtain the absolute duration graph in the Liuzhou dialect.

3 Synchronic Features and Historical Correspondences of Liuzhou Dialect Tones

3.1 Synchronic Features of Liuzhou Dialect Tones

Figure 1 illustrates the five-degree values of the monosyllabic tones in the Liuzhou dialect, with the left side for males and the right side for females (the same below), the vertical axis represents the five-degree values, and the horizontal axis represents time in milliseconds (ms).

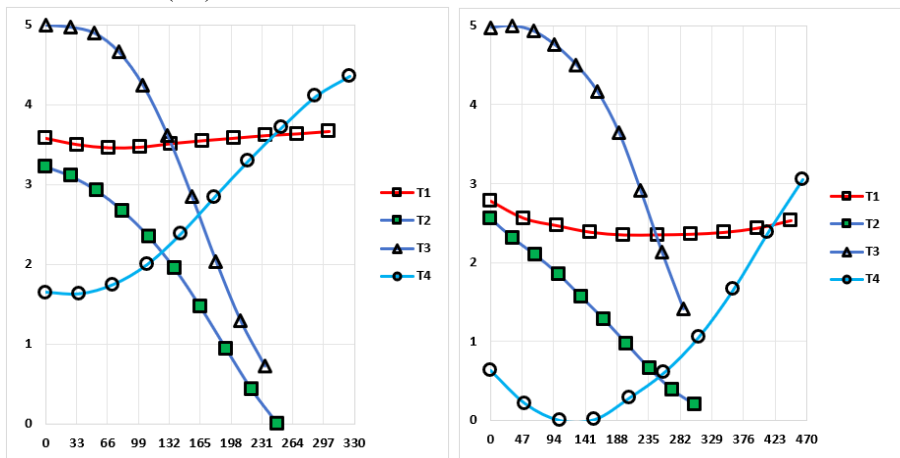


Fig. 1. Tonal Five-Degree Value Chart of Monosyllabic Words in Liuzhou Dialect

From Figure 1, it can be seen that the tonal pattern of monosyllabic words in Liuzhou dialect is the same for both males and females, with a total of 4 tones, namely the high level tone (Yin Ping), the rising tone (Yang Ping), the falling-rising tone (Shang Sheng), and the falling tone (Qu Sheng).

High Level Tone: Old male [44], old female [33], with a slight decline in the old female.

Rising Tone: Old male [41], old female [31].

Falling-Rising Tone: Old male [51], old female [52].

Falling Tone: Old male [24], old female [213], the initial small part of the old female's tone declines, while the latter majority still rises, thus it remains a rising tone.

According to Figure 1, the overall tonal pattern is: level, low falling, high falling, rising. In terms of duration, both old males and old females have the shortest rising tone and the longest falling tone.

3.2 Correspondence between Synchronic and Historical Tones in Liuzhou Dialect

1. Mean Tone Chart of Ancient Tones

Figures 2-5 respectively represent the pitch curves of the ancient level tone, rising tone, departing tone, and entering tone in Liuzhou dialect. In the figures, the vertical axis is the pitch value in Hz, and the horizontal axis is time in milliseconds (ms).

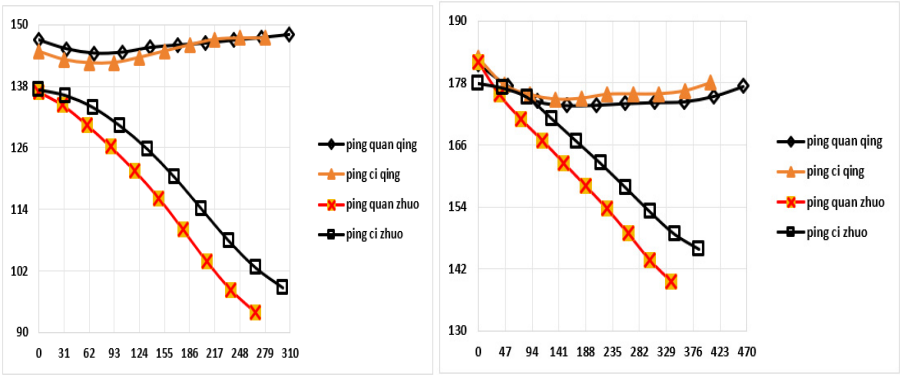


Fig. 2. Pitch Curve of Ancient Level Tone in Liuzhou Dialect

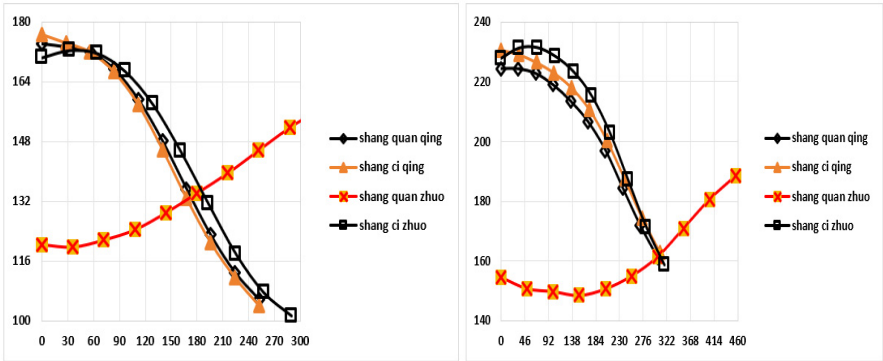


Fig. 3. Pitch Curve of Ancient Rising Tone in Liuzhou Dialect

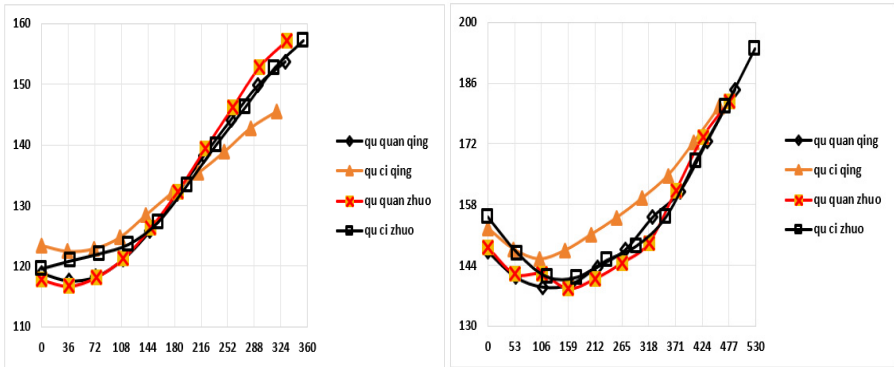


Fig. 4. Pitch Curve of Ancient Departing Tone in Liuzhou Dialect

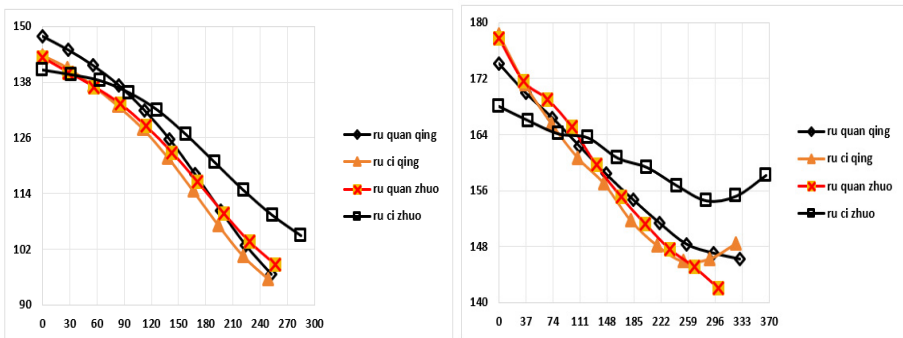


Fig. 5. Pitch Curve of Ancient Entering Tone in Liuzhou Dialect

From Figures 2-5, it can be seen that the two speakers still maintain consistency in the main types of ancient tones read in modern pronunciation. we summarize the main rules of the evolution of Liuzhou dialect tones as follows:

(1) Ancient level tone characters are divided into two categories: pure clear and secondary clear are read as Yin Ping, while fully turbid and secondary turbid are read as Yang Ping.

(2) Ancient rising tone characters are divided into two categories: fully turbid is read as Qu Sheng, and non-fully turbid is read as Shang Sheng.

(3) Ancient departing tone does not distinguish between yin and yang, and is read as Qu Sheng.

(4) Ancient entering tone does not distinguish between yin and yang, and is grouped into one category, read as Yang Ping in modern times.

4 Analysis of the Tone Sandhi Experiment Results in Two-Character Groups in Liuzhou Dialect

The two-character table is based on the tone sandhi table in Cao Zhiyun's "Chinese Dialect Atlas Investigation Manual" [8] and it mainly selects commonly used words or phrases in daily life. It includes parts of speech such as verbs, nouns, adjectives, etc., and structurally takes into account different structural types such as modifier-head, verb-object, coordinate, and subject-predicate. Referring to the two-character words in the vocabulary survey, the pitch data of the two-character groups are annotated and extracted, normalized, and the pitch patterns of each type of sandhi are obtained.

4.1 T-value Analysis of Two-Character Group Sandhi

We normalized the fundamental frequency values of the two-character tones to obtain the T-values and their curve charts of the two-character tones. Based on the analysis of the experimental results of the monosyllabic tones, the following results are obtained.

1. High Level Tone at the First Character.

The sandhi situation when the High Level Tone is at the first character is shown in Figure 6.

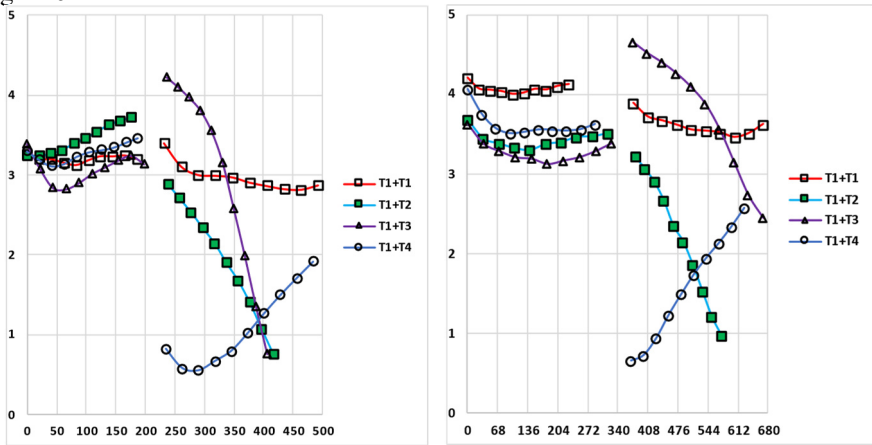


Fig. 6. Tone Sandhi of Two-Character Groups with Initial Level Tone in Liuzhou Dialect

The tone sandhi situation when the initial character is a level tone is as follows:

·Level + Level, males remain unchanged, $44+44 \rightarrow 44+44$, females remain unchanged, $33+33 \rightarrow 55+44$, such as in the words "airplane," "drive a car," "husband and wife."

·Level + Rising, males remain unchanged, $44+41 \rightarrow 44+31$, females remain unchanged, $33+31 \rightarrow 44+42$, such as in the words "open the door," "Qingming festival," "fountain pen."

·Level + Falling-Rising, males remain unchanged, 44+51→44+51, females remain unchanged, 33+52→44+53, such as in the words "village head," "granddaughter," "factory."

·Level + Departing, males remain unchanged, 44+24→44+12, females remain unchanged, 33+213→44+13, such as in the words "bus ticket," "open a shop," "distribution."

For the elderly male, when the level tone is the initial character, the tone pattern slightly rises within a tonal range, but it is still a level tone. The following character has the same tone pattern as the single character, and the tonal range of the departing tone becomes lower. For the elderly female, when the level tone is the initial character, the tone pattern remains level, but the tonal range is higher. The following character's tone pattern is consistent with the single character, the rising tone is one tonal range higher, the tonal range of the falling-rising tone widens, and the slight fall in the first half of the departing tone disappears.

2. Rising Tone as the Initial Character.

The tone sandhi situation when the rising tone is the initial character is shown in Figure 7.

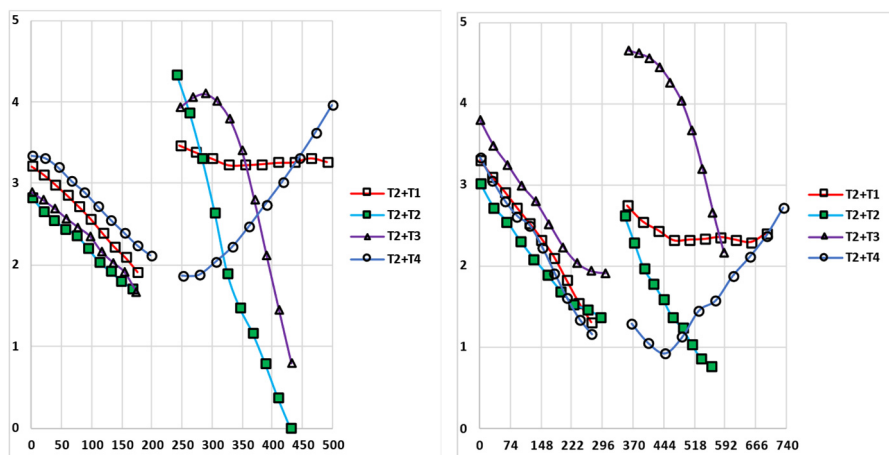


Fig. 7. Tone Sandhi of Two-Character Groups with Initial Rising Tone in Liuzhou Dialect

The tone sandhi situation when the initial character is a rising tone is as follows:

·Rising + Level, males remain unchanged, 41+44→42+44, females remain unchanged, 31+33→43+33, such as in the words "country," "rural," "read a book."

·Rising + Rising, males remain unchanged, 41+41→43+31, females remain unchanged, 31+31→42+31, such as in the words "farmer," "iron gate," "shake one's head."

·Rising + Falling-Rising, males remain unchanged, 41+51→32+41, females remain unchanged, 31+52→42+53, such as in the words "take by hand," "entrance," "friend."

·Rising + Departing, males remain unchanged, 41+24→32+24, females remain unchanged, 31+213→42+213, such as in the words "city," "agree," "line up."

When the rising tone is the initial character, both elderly males and females have a low falling tone, but the tonal range of elderly males narrows, and the tonal range of elderly females becomes higher. The following character's tone pattern is consistent with the single character; the tonal range of the rising tone in elderly males becomes lower, and the tonal range of the falling-rising tone in elderly females narrows.

3. Falling-Rising Tone as the Initial Character.

The tone sandhi situation when the falling-rising tone is the initial character is shown in Figure 8.

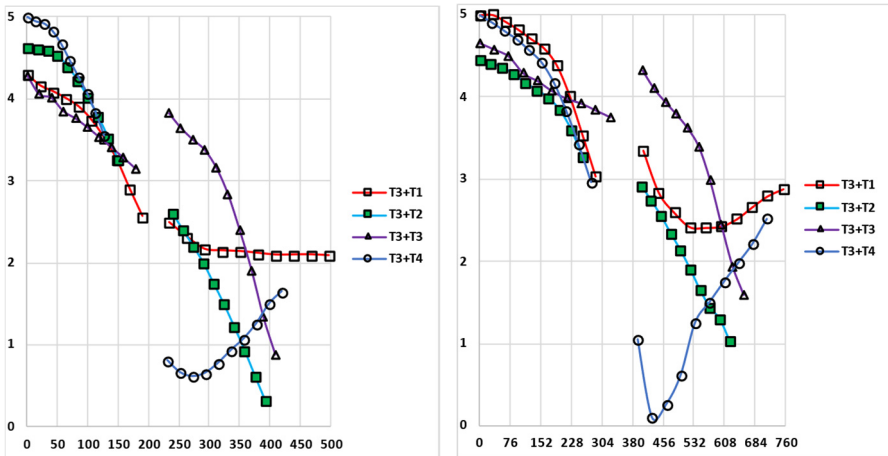


Fig. 8. Tone Sandhi of Two-Character Groups with Initial Falling-Rising Tone in Liuzhou Dialect

The tone sandhi situation when the initial character is a falling-rising tone is as follows:

- Falling-Rising + Level, males remain unchanged, 51+44→53+33, females remain unchanged, 52+33→54+33, such as in the phrases "dim sum," "injection," "for example."

- Falling-Rising + Rising, males remain unchanged, 51+41→54+31, females remain unchanged, 52+31→54+32, such as in the phrases "chalk," "raise cattle," "inspection."

- Falling-Rising + Falling-Rising, males remain unchanged, 51+51→54+41, females remain unchanged, 52+52→54+52, such as in the phrases "ham," "cold water," "retirement."

- Falling-Rising + Departing, males remain unchanged, 51+24→54+12, females remain unchanged, 52+213→54+113, such as in the phrases "write a letter," "distance," "full moon."

When the falling-rising tone is the initial character, both elderly males and females have a high falling tone, but the tonal range of both narrows. The following character's tone pattern is consistent with the single character; the tonal range of elderly males becomes lower, and the tonal range of the rising tone in elderly females narrows.

4. Departing Tone as the Initial Character.

The tone sandhi situation when the departing tone is the initial character is shown in Figure 9.

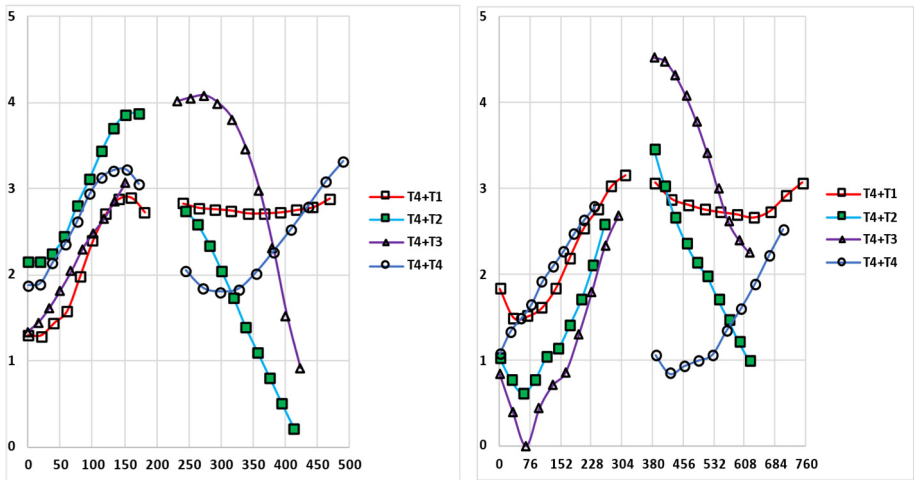


Fig. 9. Tone Sandhi of Two-Character Groups with Initial Departing Tone in Liuzhou Dialect

The tone sandhi situation when the initial character is a departing tone is as follows:

·Departing + Level, males remain unchanged, 24+44→23+33, females remain unchanged, 231+44→24+33, such as in the phrases "truck," "sing a song," "health."

·Departing + Rising, males remain unchanged, 24+41→34+31, females remain unchanged, 231+31→13+42, such as in the phrases "morality," "take a boat," "tree leaves."

·Departing + Falling-Rising, males remain unchanged, 24+51→23+41, females remain unchanged, 213+52→13+13, such as in the phrases "give a gift," "county head," "reason."

·Departing + Departing, males remain unchanged, 24+24→24+224, females remain unchanged, 213+213→23+23, such as in the phrases "town," "great fortune," "grow vegetables."

When the departing tone is the initial character, both elderly males and females have a rising tone. Elderly males have a narrower tonal range when combined with level, rising, and falling-rising tones; elderly females lose the descending part in their single-character tones. The following character's tone pattern is consistent with the single character; the tonal range of elderly males' rising tone becomes lower, the departing tone has an additional descending bend at the beginning, but the descent within one tonal range does not affect the tone pattern; the tonal range of elderly females' rising tone becomes higher, the falling-rising tone's tonal range narrows, and the descending part of the departing tone is gone.

5 Conclusion

In summary, the study concludes that the tonal patterns of single-character speech in Liuzhou dialect for both males and females are consistent, divided into four tones: Yin Ping, Yang Ping, Shang Sheng, and Qu Sheng. The tonal configuration is as follows: Yin Ping is a level tone, Yang Ping is a low-falling tone, Shang Sheng is a high-falling tone, and Qu Sheng is a rising tone. The historical correspondences are as follows: level tones are divided into Yin and Yang, all voiced initials are merged into the Qu Sheng tone, and the Qu Sheng tone does not distinguish between Yin and Yang, while the entering tone is read as Yang Ping. The four tones of Liuzhou dialect have retained the main tone patterns of the single-character tones in two-character group sandhi, with little change in tone values and no change in tone patterns, hence no tone sandhi has occurred. Compared with the single-character tones, there are subtle changes in the tone values of each tone in the connected speech, which belong to tonal variants.

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